

March 2004

TACTICAL AIRCRAFT

Changing Conditions Drive Need for New F/A-22 Business Case



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Highlights of [GAO-04-391](#), a report to congressional committees

Why GAO Did This Study

Following a history of increasing cost estimates to complete F/A-22 development, Congress asked GAO to assess the Air Force's F/A-22 development program annually and determine whether the Air Force is meeting key performance, schedule, and cost goals. On April 23, 2003, a congressional subcommittee requested that the Department of Defense (DOD) provide more detailed information on the business case that supports the estimated quantities and costs for an affordable F/A-22 program. Specifically, GAO (1) identified changes in the F/A-22 program since its inception, (2) reviewed the status of the development activities, and (3) examined the sufficiency of business case information provided for congressional oversight.

What GAO Recommends

GAO recommends that DOD complete a new business case that determines the continued need for the F/A-22 and the number of aircraft required for its air-to-air and air-to-ground roles based on capabilities, need, alternatives, and constraints of future defense spending departmentwide. GAO also recommends that plans and costs for resolving problems identified during initial operational testing be provided to the defense committees prior to the department's full rate production decision. DOD partially concurred with both recommendations. GAO believes a business case and the plans and costs of corrective action should be reported to Congress.

www.gao.gov/cgi-bin/getrpt?GAO-04-391.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Allen Li at (202) 512-4841 or lia@gao.gov.

TACTICAL AIRCRAFT

Changing Conditions Drive Need for New F/A-22 Business Case

What GAO Found

The Air Force is developing the F/A-22 aircraft to be less detectable to adversaries, capable of high speeds for long ranges, and able to provide a pilot with improved awareness of the surrounding situation through integrated avionics. In addition, the Air Force plans to expand the F/A-22's ability to engage targets on the ground to provide a robust capability not originally planned at the start of the program. The Air Force plans to begin initial operational test and evaluation in March 2004 and to seek full rate production approval in December 2004.

The F/A-22 program has experienced several significant changes since it began development in 1986. First, the Air Force cannot afford to purchase the quantities of aircraft that were planned 18 years ago. The Air Force had originally planned to buy 750 aircraft, but it now estimates it can only afford 218 aircraft. Second, in order to develop the expanded air-to-ground attack capability, the Office of Secretary of Defense estimates that the Air Force will need \$11.7 billion in modernization funding. Lastly, the Air Force has determined that new avionics computer processors and architecture are needed to support most planned enhancements, which will further increase program costs and risk.

Further, the development test program continues to experience problems and risks further delays. The F/A-22's avionics continue to experience shutdowns and failures. Moreover, the F/A-22 has not met its reliability requirements and has experienced failures in its computerized maintenance support system. This has led to aircraft spending more time on the ground undergoing maintenance.

Due to the risks of future cost increases and schedule delays, a congressional subcommittee requested that DOD provide business case information on the F/A-22. However, the information DOD provided did not address why this aircraft is needed given current and projected threats. The business case also did not address how many aircraft the Air Force needs to accomplish its missions, how many the Air Force can afford considering the full life-cycle costs, whether investments in new air-to-ground capabilities are needed, and what are the opportunity costs associated with purchasing any proposed quantities of this aircraft. While the response stated that the Air Force still plans to buy 277 F/A-22 aircraft, the Air Force estimates that only 218 aircraft are affordable within congressionally imposed funding limitations. In addition, significant investment decisions remain and could affect another \$40 billion to support this program through full rate production and implementation of the spiraled improvement efforts.

In light of the uncertainty concerning how many aircraft are needed in today's environment, the large investments that remain, and unknown outcomes of planned operational testing, GAO continues to have concerns regarding the DOD's readiness to make a full rate production decision.

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Abbreviations

CAIG	Cost Analysis Improvement Group
CIP	common integrated processors
DOD	Department of Defense
MTBAA	Mean Time Between Avionics Anomaly
MTBIE	Mean Time Between Instability Events
IOT&E	initial operational test and evaluation

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United States General Accounting Office
Washington, DC 20548

March 15, 2004

Congressional Committees

The Air Force is developing the F/A-22 aircraft to be an air superiority and ground attack aircraft with advanced features to make it less detectable to adversaries, capable of high speeds for long ranges, and able to provide a pilot with improved awareness of the surrounding situation. The ability to engage targets on the ground is being expanded to provide a robust capability not originally planned at the start of the program.¹ The Air Force plans to begin initial operational test and evaluation (IOT&E) to demonstrate the aircraft's operational effectiveness and suitability in March 2004 and to seek full rate production approval in December 2004.

The National Defense Authorization Act for Fiscal Year 1998 requires us to assess the Air Force's F/A-22 development program annually and determine whether the Air Force is meeting key performance, schedule, and cost goals.² The Chairman of the Subcommittee on Tactical Air and Land Forces, House Committee on Armed Services, asked us to continue monitoring the F/A-22 development program during a hearing on April 2, 2003. On April 23, 2003, the Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, asked the Department of Defense (DOD) to provide more detailed information on the business case that supports the estimated quantities and costs for an affordable F/A-22 program. In response to the concerns and directions of these various committees, we (1) identified changes in the F/A-22 program since its inception, (2) reviewed the status of the development activities, and (3) examined the sufficiency of business case information provided for congressional oversight.

We performed our work from July 2003 through March 2004 in accordance with generally accepted government auditing standards.

¹ As a result, in September 2002 the Air Force changed the aircraft's designation from F-22 to F/A-22, which includes increased emphasis on acquiring an improved air-to-ground capability.

² Pub. L. 105-85 (Nov. 18, 1997), section 217.

Results in Brief

The F/A-22 program has experienced several significant changes since it began development in 1986. First, the Air Force cannot afford to purchase the quantities of aircraft that were planned 18 years ago. The Air Force had originally planned to buy 750 aircraft, but it now estimates it can only afford 218 aircraft under the congressionally imposed limit on production funding. Development costs have grown 127 percent, to \$28.7 billion, and the program could incur further cost growth before development and testing is completed. This reduction in buying power and increased costs are largely a result of the program's failure to base acquisition decisions on high levels of knowledge at critical junctures in the development program.³ Second, the Air Force has decided to add a robust air-to-ground attack capability not previously envisioned but now considered necessary to increase the utility of the aircraft. The Office of Secretary of Defense estimated the Air Force would need as much as \$11.7 billion to develop the expanded capability. Lastly, the Air Force has determined that new avionics computer processors and architecture are needed to support some planned enhancements, which will further increase program costs and risk.

The development test program continues to experience problems and risks further delays. The F/A-22's advanced avionics system—which allows a pilot to have better control of information regarding the surrounding situation—frequently failed, delaying earlier testing, and must now be proven stable before IOT&E can start. The F/A-22's avionics system continues to experience shutdowns and failures. Recently, the Air Force established a new criterion to measure the stability of the avionics software and hardware and its readiness to begin IOT&E. The new criterion is more comprehensive but requires fewer hours of operation before a failure occurs than the original criterion. To date, the program has not met the new criterion. In addition, the F/A-22 program has not met its reliability requirements, resulting in aircraft spending more time on the ground undergoing maintenance. Further, the program has experienced failures in its computerized maintenance support system, which have prevented maintenance crews from correctly diagnosing and addressing problems on the aircraft. As a result of the problems with the development

³ U.S. General Accounting Office, *Best Practices: Better Acquisition Outcomes Are Possible If DOD Can Apply Lessons from F/A-22 Program*, [GAO-03-645T](#) (Washington, D.C.: Apr. 11, 2003). We testified on the failure to use these best practice acquisition concepts in the F/A-22 program and used the F/A-22 program as a case study to show lessons to be learned had the F/A-22 applied this best practice approach in its development and procurement activities.

test program, the start of IOT&E has been delayed, and the time to complete it has been compressed by 4 months. Additional delays in completing IOT&E could jeopardize the full rate production decision in December 2004.

Due to significant changes to the program and the risks of future cost increases and schedule delays, a congressional subcommittee requested that DOD provide business case information on the F/A-22.⁴ However, the information provided by DOD did not address how many aircraft the Air Force needs to accomplish its missions, how many the Air Force can afford, and whether investments in new air-to-ground capabilities are needed. Instead, the information shows that the Air Force still plans to buy 277 F/A-22 aircraft despite estimates that state it can only afford 218 aircraft and the potential for further reduction in buying power from cost increases in the development program. In the past, reducing the amount of funds available in the procurement budget has offset development cost growth. This is a part of DOD's "buy to budget" plan. If the current congressionally imposed production cap of \$36.8 billion is maintained and the Air Force uses more procurement funds to address higher development costs, the number of F/A-22 aircraft the Air Force could buy would be reduced.

We are making recommendations that DOD complete a new business case that justifies the continued need for the F/A-22 and determines the number of F/A-22 aircraft needed in its air-to-air and air-to-ground roles based on capabilities, need, alternatives, and constraints of future defense spending departmentwide. We also recommend that the results of IOT&E be provided to the defense committees prior to making the full rate production decision. In written comments on a draft of this report, DOD stated that it partially concurred with our recommendations.

Background

The F/A-22 is planned to be an air superiority and ground attack aircraft with advanced features to make it less detectable to adversaries (stealth characteristics) and capable of high speeds for long ranges.⁵ It has

⁴ The Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, requested the F/A-22 business case information as a result of the April 11, 2003, hearings.

⁵ Air superiority is the degree of air dominance that allows the conduct of operations by land, sea, and air forces without prohibitive interference by the enemy.

integrated avionics that greatly improve pilots' awareness of the situation surrounding them. The objectives of the F/A-22 development program are to (1) design, fabricate, test, and deliver 9 F/A-22 development test aircraft, 2 nonflying structural test aircraft, 6 production representative test aircraft, and 37 flight-qualified engines; (2) design, fabricate, integrate, and test the avionics; and (3) design, develop, and test the support and training systems. The F/A-22 is being developed under contracts with Lockheed Martin Corporation, the prime contractor (for the aircraft), and Pratt & Whitney Corporation (for the engine).

Following a history of increasing cost estimates to complete the development phase of the F/A-22 program, the National Defense Authorization Act for Fiscal Year 1998 established a cost limitation for both the development and the production.⁶ Subsequently, the National Defense Authorization Act of 2002 eliminated the cost limitation for the development, but it left the cost limit for the production.⁷ The production program is now limited to \$36.8 billion.⁸ The current cost estimate of the development program is \$28.7 billion.

Currently, the F/A-22 program is both in development and production. Development is in its final stages, and production has been ongoing since fiscal year 1999.

The aircraft's development problems and schedule delays in completing flight testing have led to congressional concerns. The National Defense Authorization Act for Fiscal Year 2004 prohibited the obligation of \$136 million in procurement funds until the Under Secretary of Defense, Acquisition, Technology, and Logistics, submitted to the congressional defense committees, among other things, a certification that the avionics software installed on test aircraft can operate at least 5 hours on average before certain types of avionics anomalies occur. The Under Secretary of Defense, Acquisition, Technology, and Logistics, the final authority in making acquisition decisions in DOD, has also included this criterion as a requirement for the F/A-22 program before entering IOT&E .

⁶ Pub. L. 105-85 (Nov. 18, 1997), section 217.

⁷ Pub. L. 107-107 (Dec. 28, 2001), section 213.

⁸ The cost limitation, before adjustment under the act's provisions, was \$43.4 billion.

Significant Changes Have Occurred in the F/A-22 Program during Nearly Two Decades of Development

The F/A-22 program has experienced several significant changes since it began development in 1986. First, the Air Force cannot afford to purchase the quantities of aircraft that were originally planned 18 years ago. This reduction in buying power is attributed, in a large part, to increases in development time and cost due to the program's failure to employ a knowledge-based acquisition approach to developing the F/A-22. Second, in September 2002, the Air Force decided to add a more robust air-to-ground attack capability than previously envisioned but now deemed needed to increase the utility of the aircraft. This capability will add significant cost to the program over the next 10 years. Lastly, the Air Force has determined that new computer processors and architecture are needed to support some planned enhancements, which will further increase program costs and risk.

Delays and Higher Costs Have Reduced DOD's Buying Power

Since the F/A-22 acquisition program started in 1986, cost and schedule estimates have grown significantly, thus contributing to a loss in buying power. Development costs are now estimated at \$28.7 billion, a 127 percent increase over the 1986 estimates. Planned development cycle time has grown from 9 years to 19 years, and the initial operational capability date has slipped over 9 years, from March 1996 to December 2005. These schedule extensions, delays, and cost increases were major contributors to changes in the Air Force's initial plan to purchase 750 aircraft. Current Air Force budget estimates include plans to purchase 277 aircraft. Table 1 shows the changes in the F/A-22 program since its start in 1986 based on information provided in Selected Acquisition Reports⁹ over time.

⁹ Selected Acquisition Reports are standard, comprehensive, summary status reports of major defense acquisition programs (acquisition category I) required for periodic submission to Congress. They include key cost, schedule, and technical information.

Table 1: Changes in F/A-22 Program Estimates Since It Started in 1986

	1986—Start of demonstration and validation	1991—Start of engineering and manufacturing development	2002—Current available Selected Acquisition Report information
Development cost	\$12.6 billion	\$19.5 billion	\$28.7 billion
Development cycle time	9 years	16 years	19 years
Development test and evaluation	Not estimated	51 months	99 months
Initial operational capability	March 1996	Not shown in report	December 2005
Quantities	750	648	276 ^a

Sources: Selected Acquisition Reports and Air Force documents.

Note: All references to F/A-22 costs in this report are in then-year dollars in order to maintain consistent reporting with our prior reports on the F/A-22 aircraft.

^aIn fiscal year 2003, the Air Force increased the number of F/A-22 aircraft it planned to buy from 276 to 277.

In our 1988 report, the average unit procurement cost was estimated by the Air Force to be \$69 million.¹⁰ Today, after schedule delays and development problems, the estimated average unit procurement costs have grown to \$153 million—almost a 122 percent increase. The Air Force does not expect the development program to be completed until 2005 and with IOT&E still to be completed, the possibility of additional changes and costs is likely.

As we previously reported,¹¹ the acquisition approach of the F/A-22 program has contributed to cost increases and delays in schedule. Leading commercial firms that we studied employ an acquisition approach that evolves a product to its ultimate capabilities on the basis of mature technologies and available resources. Further, product enhancements are planned for subsequent development efforts only when technologies are proven to be mature and other resources are available. Our work has shown that commercial firms ensure that high levels of knowledge exist at three critical junctures in a development program. First, a match must be made between a customer’s needs and the available resources—technology, engineering knowledge, time, and funding—before a new development program is launched. Second, a product’s design must

¹⁰ U.S. General Accounting Office, *Aircraft Development: The Advanced Tactical Fighter’s Costs, Schedule, and Performance Goals*, [GAO/NSIAD-88-76](#) (Washington, D.C.: Jan. 13, 1988).

¹¹ [GAO-03-645T](#).

demonstrate its ability to meet performance requirements and be stable about midway through development. Third, the developer must show that the product can be manufactured within cost, schedule, and quality targets and is demonstrated to be reliable before production begins.

In contrast, the F-22 acquisition strategy from the outset was to achieve full capability in a “big bang” approach instead of evolving development in manageable increments of new capability. By not using an evolutionary approach, the Air Force took on significant risk and onerous technology challenges. The three critical technologies that were immature at the start of the program included low-observable materials, propulsion, and integrated avionics. Integrated avionics has been a source of major schedule delays and cost increases in the F/A-22 program. Starting the program with these immature technologies prevented the program from knowing cost, schedule, and performance ramifications until late in the development program, after significant investments had already been made. Efforts to mature technology cascaded into development, delaying attainment of design and production maturity. The overall result has been significant delays and substantially higher investments to buy over 60 percent fewer aircraft.

Additional Investments Needed to Expand F/A-22 Capability

Developing an expanded air-to-ground attack capability for the F/A-22 will be costly and add risk to the program. The Air Force began development of the F/A-22 as a replacement for the F-15 air superiority fighter with primary emphasis on the air-to-air role. It was never intended to have robust air-to-ground capability. Its need was based on a projection that the Soviet Union would develop and produce large numbers of advanced fighter aircraft. The F/A-22 was intended to identify, track, and kill advanced fighters before it was targeted, giving it the edge and making it a more lethal and survivable aircraft than an F-15. However, the original Soviet threat never materialized. To enhance the utility of the F/A-22, the Air Force plans to develop a robust air-to-ground attack capability to be able to engage a greater variety of ground targets, such as surface-to-air missile systems, that have posed a significant threat to U.S. aircraft in recent years.

The Air Force has a modernization program to improve the capabilities of the F/A-22 focused largely on a new robust air-to-ground capability. It has five developmental spirals planned over more than a 10-year period, with the initial spiral started in 2003. Table 2 shows each spiral as currently planned. In March 2003, the Office of Secretary of Defense’s Cost Analysis Improvement Group (CAIG) estimated that the Air Force would need

\$11.7 billion for the planned modernization program. The CAIG estimate included costs for development, production, and the retrofit of some aircraft. As of March 2003, the Air Force F/A-22 approved program baseline did not include estimated costs for the full modernization effort. Instead, the Air Force estimate included \$3.5 billion for modernization efforts planned through fiscal year 2009.

Table 2: Planned Modernization Enhancements for the F/A-22 Program

	Fiscal year expected to incorporate enhancements			
	2007	2011	2013	2015
Developmental spiral	Global Strike Basic	Global Strike Enhanced ^a	Global Strike Full	Enhanced Intelligence, Surveillance, and Reconnaissance
Examples of enhancements to be added	Capability to launch Joint Direct Attack Munition at faster F/A-22 air speeds and at longer distances and update to air-to-air capabilities.	Improved radar capabilities to seek and destroy advanced surface-to-air missile systems and integrate additional air-to-ground weapons.	Increased capability to suppress or destroy the full range of air defenses and improve speed and accuracy of targeting.	Capability for full intelligence, surveillance, and reconnaissance integration for increased target sets and lethality.
Cost Analysis Improvement Group's estimate through fiscal year 2015				\$11.7 billion

Sources: Air Force and Office of Secretary of Defense.

^a The Global Strike Enhanced includes two developmental spirals to achieve the planned enhanced capability.

New Computer Architecture and Avionics Processors Needed to Support Expanded Capability

To support the F/A-22's expanded capability beyond Global Strike Enhanced, the Air Force has determined that its baseline computer architecture and critical avionics processors will need to be replaced. Current processors are old and obsolete, cannot be supported, and do not have sufficient capacity to meet the increased processing demands required for planned new air-to-ground capabilities beyond Global Strike Enhanced. As a bridge to meet this expanded capability, the Air Force plans to modify some avionics processors and purchase sufficient quantities to support production of the first 155 F/A-22 aircraft.

The F/A-22 is dependent on its onboard computers and software to perform its mission. Unlike other fighter aircraft, it has a highly advanced, integrated avionics system capable of detecting, identifying, and engaging the enemy at ranges beyond a pilot's vision. The key to the F/A-22 avionics

lies in its fully integrated core architecture and its two central, networked computers called common integrated processors (CIP). CIPs use very high-speed integrated circuits to collect, process, and integrate data and signals from the aircraft's sensors. CIP serves as the "brains" for the F/A-22's integrated avionics system and is unique to this aircraft.

The primary processor in CIP is the Intel i960MX microprocessor,¹² which is used strictly for avionics processing. This microprocessor is based on 1990's technology and has a 32-bit processor that operates at speeds of 25mhz. By today's technology standards, the processor is considered obsolete and cannot support spiral developments beyond the Global Strike Enhanced. In mid-2003, the manufacturer of the microprocessor informed the Air Force that it planned to permanently shut down the i960MX production line by January 2004 because the microprocessor was no longer a viable product for the company.

As a result, the Air Force decided in November 2003 to replace its computer architecture and avionics processors to support the F/A-22's expanded capabilities. In December 2003, the Air Force purchased its last i960MX microprocessors when it bought 820 of the microprocessors. According to program officials, this quantity and previously purchased quantities are sufficient to support production of 155 F/A-22 aircraft. These officials believe that with some minor upgrades to improve processing capacity, these processors will be able to support the baseline aircraft and the developmental spirals—Global Strike Basic and Global Strike Enhanced. However, the Air Force plans for the remaining production aircraft to include a new computer architecture and avionics processor needed to support the final two planned spirals—Global Strike Full and Enhanced Intelligence, Surveillance, and Reconnaissance.

At the time of our review, the Air Force believed its best long-term solution to its avionics architecture and computer-processing shortfalls was a new, modern, open system architecture. Rather than start a new development program, the program office plans to leverage two other ongoing Air Force development or modification programs for this processing capability: the new architecture being developed for the F-35 and the new commercial off-the-shelf general-purpose processors designed for newer versions of the F-16. According to F/A-22 program officials, this new architecture will be state-of-the-art and will have ample

¹² The i960MX microprocessor is a registered trademark of the Intel Corporation.

processing capacity to accommodate all future air-to-ground capabilities as currently planned. These officials do not expect the new architecture to be fully developed and ready for installation in the F/A-22 for at least 5 to 6 years.

F/A-22 program officials acknowledge that this mass changeover of the F/A-22 computer architecture and avionics processor will be a time-consuming and costly effort and will likely create additional program risks. Air Force cost estimates are not yet available. Nevertheless, program officials estimate the nonrecurring engineering costs alone could be at least \$300 million. At the time of our review, the Air Force had not made a decision about retrofitting aircraft equipped with the i960MX microprocessor. Additional risks are likely because the new processor and architecture are being developed by other major aircraft programs and will require extensive integration and operational testing to ensure that the F/A-22 program does not encounter similar problems that have delayed integration and testing of the F/A-22's current avionics suite.

Remaining Development and Operational Testing Could Impact F/A-22 Program Outcomes

The F/A-22 program did not meet key testing goals established for fiscal year 2003 and required for the aircraft to begin IOT&E testing. The Air Force's efforts to stabilize avionics software and improve its performance have not been sufficiently demonstrated, and entrance criterion previously set for starting IOT&E testing has been changed. In addition, the F/A-22 program is not performing as expected in some other key performance areas, including reliability and maintenance support. The ongoing problems have led to a revised test schedule, which has compressed the time to complete initial operational testing by 4 months, and have increased the potential for cost increases and delays in the full rate production decision. The program has made progress in correcting several of the design problems we identified in our March 2003 report.

Air Force Changed Avionics Performance Criterion to Start Operational Testing

The Air Force changed the avionics stability metric planned as a criterion to enter IOT&E from an average of 20 hours between avionics software failures to a broader measure of an average of 5 hours between avionics software or hardware failures. Current testing shows the program continues to have problems meeting the new and old avionics stability metrics.

Because the F/A-22 avionics encountered frequent shutdowns over the last few years, many test flights were delayed. As a result, the Air Force Operational Test and Evaluation Center wanted assurances that the

avionics would work before it was willing to start the IOT&E program. It established a requirement for a 20-hour performance metric that was to be demonstrated before IOT&E would begin. The metric was Mean Time Between Instability Events (MTBIE)¹³ and tracked two distinct types of avionics software failures:

- Hard failures (type 1) that were the most serious resulting in a complete avionics system shutdown requiring the need to restart the avionics system.
- Significant failures (type 2) that were less serious failures but required the pilot to restart an individual subsystem that failed versus the complete avionics system.

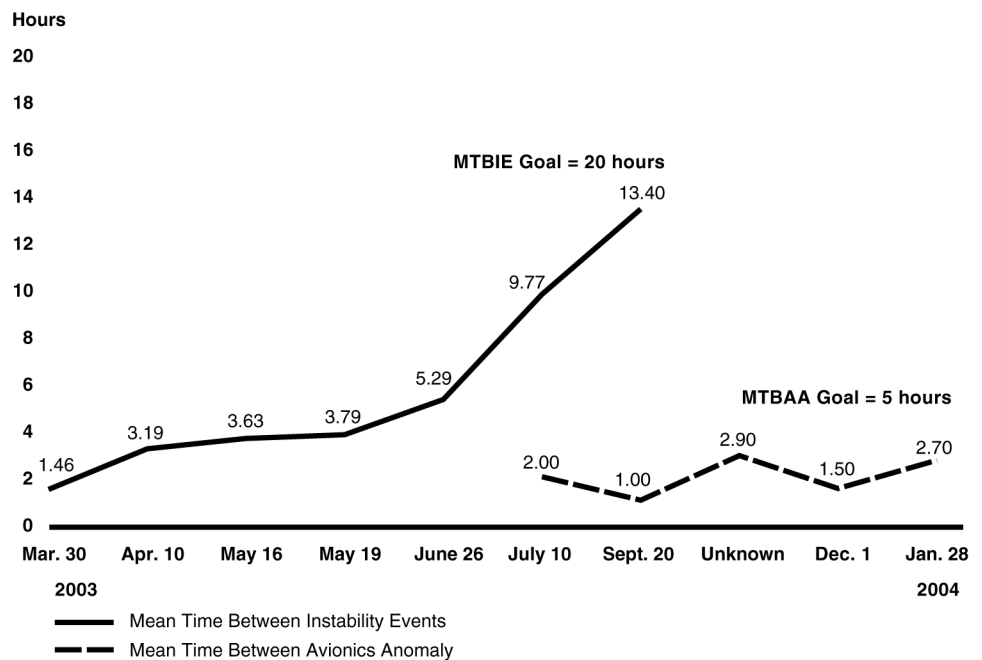
Using personal computers as an analogy, a type 1 failure would be equivalent to a failure of one's personal computer that requires it to be shut down and rebooted, except that the time to restart the F/A-22 avionics system could take substantially longer. A type 2 failure would be equivalent to a failure in a particular application, such as the word processing program shutting down. Even with such a failure, other software applications could still be operated while the word processing software was restarted. Likewise, in the case of the F/A-22, other applications would still be operable despite the failure of any single application, such as a shutdown in the communication, navigation, and identification system.

In July 2003, the Air Force decided to switch to a different metric—Mean Time Between Avionics Anomaly (MTBAA)—to measure the performance of the avionics software for the start of IOT&E. Two main differences between the new metric and its predecessor are the new metric (1) includes hardware and some subsystem software failures not previously counted and (2) requires a failure rate based on an average of 5 hours without experiencing avionics anomalies, instead of 20 hours. According to Air Force operational test officials, they adopted this new metric because they believe it is a better measure of the avionics operational performance needed to start IOT&E, whereas the previous metric was more technically focused on software performance, excluding hardware failures. They also said the 5-hour criterion would provide a minimum amount of effective operational test time to efficiently conduct

¹³ MTBIE is the ratio of the total hours the avionics are turned on divided by the number of countable instability events averaged over multiple flights. It was derived by conducting dedicated stability flights, nominally six flights of 2.5 hours duration each.

IOT&E. In turn, Congress included the new metric in the National Defense Authorization Act for Fiscal Year 2004.¹⁴ Testing as of January 2004 showed the program had achieved 2.7 hours—54 percent of the requirement. Once this criterion is achieved, the avionics must still undergo rigorous operational testing to demonstrate its effectiveness and suitability in a realistic environment. Figure 1 shows the status of the MTBIE and MTBAA metrics.

Figure 1: Status of F/A-22 Avionics Metrics, as of January 2004



Sources: Lockheed Martin and Air Force.

Note: MTBIE is no longer tracked by the Air Force.

The figure shows that MTBIE, the previous criterion, was demonstrated at about 67 percent of the requirement. In addition, the type 1 failures, causing a complete shutdown of the avionics system, have significantly diminished. They are occurring only about once every 25 hours on average. This is the result of a substantial effort on the part of the Air Force and the contractor to identify and fix problems that led to the instability in the F/A-22 avionics software. Type 2 failures are still

¹⁴ Pub. L. 108-136 (Nov. 24, 2003), section 133.

occurring frequently. While less serious when compared to the entire avionics suite shutting down, type 2 failures become serious if critical subsystem software shuts down when its function is needed for the success of the mission or survivability of the aircraft.

In September 2003, the F/A-22 contractor reported a high number of outstanding avionics Common Problem Reports.¹⁵ Of the 231 reports of problems not resolved, about 25 (or 11 percent) were identified as stability-related problems. The remaining 206 reports (89 percent) were the result of avionics performance or functional problems. For example, the communication, navigation, and identification subsystem accounted for nearly 36 percent of the total reports. Because the avionics system is essential to the success of the F/A-22, the integrated avionics still needs to be demonstrated to meet design specifications and operational requirements. Reductions in avionics performance could affect the ability of the F/A-22 to effectively carry out its expected missions.

Reliability Requirements Not Being Met

The F/A-22 program is not meeting its requirements for a reliable aircraft and it is not using a best practice approach. The Air Force established reliability requirements to be achieved at the completion of development and at system maturity.¹⁶ As a measure of the system's overall reliability, the Air Force established a requirement for 1.95-hours mean time between maintenance by the completion of development, and 3-hours mean time between maintenance at system maturity. This measure of reliability represents the average flight time between maintenance actions. As of October 2003, the Air Force had only been able to demonstrate a reliability of about 0.5 flying hours between maintenance actions or about 26 percent of the development requirement and 17 percent of system maturity requirement. This has led to the development test aircraft spending more time than planned on the ground undergoing maintenance.

During 2003, the Air Force identified 68 parts that had a high rate of failure causing them to be removed or replaced, affecting the F/A-22 system reliability. The contractor has initiated programs to eliminate the high failure rates experienced by these parts. The canopy has also been

¹⁵ Common Problem Reports are used to identify problems within the aircraft avionics.

¹⁶ System maturity is defined by the Air Force as a point when the F/A-22s have accumulated 100,000 flying hours, expected to occur in 2008 after most F/A-22s are to be procured.

experiencing failures during testing, allowing it to achieve only about 15 percent of its expected 1,600-hour life. A second manufacturer for canopies is being developed, but until it has passed qualification testing, it cannot be used as an alternative source for the high failing canopies.

Best commercial practices for new product development require reliability to be demonstrated by the start of production. Our work has shown that product development engineers from leading commercial firms expect to achieve reliability requirements before entering production. They told us reliability is attained through an iterative process of design, test, analyze, and redesign.¹⁷ Commercial firms understand that once a system enters production, the costs to achieve reliability through this iterative design change process become significantly more expensive. The F/A-22 aircraft has been in production since fiscal year 1999, and the Air Force has on contract 52 production aircraft, and an additional 22 aircraft on long lead contracts representing 27 percent of the planned buy quantity. With 83 percent of the reliability requirement yet to be achieved through this iterative design change process, the Air Force can expect to incur additional development and design change costs. If the Air Force fails to improve the F/A-22's reliability before fielding the aircraft, the high failure rates will result in higher operational and support costs to keep the aircraft available for training or combat use.

Immaturity of Maintenance Support Systems

The F/A-22 is designed to have a computerized and paperless maintenance system that monitors, diagnoses, identifies, and reports failures to maintenance crews and that is intended to allow a faster maintenance turnaround to flight status. The onboard Diagnostics Health and Management system constantly monitors the aircraft's systems and the performance of both hardware and software. It collects, analyzes, stores, and reports failures. Critical failures are reported to the pilot, and all failures are stored in a portable database for later use by ground maintenance crews. At the completion of a flight, the database is removed from the aircraft and is downloaded into a system on the ground, the Integrated Management Information System, which is a network of computers the maintainers use to process the maintenance and support information. This system further analyzes the downloaded information to

¹⁷ U.S. General Accounting Office, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002).

determine the problems and match failures with the appropriate digitized technical order data needed to make the repairs. This information is then loaded into handheld portable computers that the technicians use to repair the aircraft.

According to DOD and Air Force test officials, these systems have been generating false reports of failures, which have caused maintenance staff to spend more hours than planned replacing items unnecessarily and trying to identify the actual problems. In addition, the maintenance systems are not providing all the technical data needed to repair the aircraft, thus making it more difficult to make repairs. According to the test officials, they do not have precise data to quantify the extent of the problems, and they said it has disrupted maintenance activities. A key indication has been the inability to fly aircraft as planned. We found that between October 2003 and January 2004 the test force could only fly about 53 percent of the planned test flights and that the maintenance problems were a key contributor to this poor flying performance.

Air Force officials do not expect the maintenance systems to be fully matured until December 2005. Consequently, the program office has had to provide additional funding to the contractor to purchase special test equipment that will be used to support maintenance requirements during operational testing. Moreover, because these systems will not be fully available during the operational testing, it may be difficult to assess the systems' real performance.

Problems in the Development Program Have Led to Further Delays and Changes in Operational Testing

Progress in F/A-22 flight testing was slower than expected in 2003, and start of IOT&E was delayed an additional 7 months due to avionics and other problems. Realizing the Air Force would not be ready to enter initial operational testing as previously planned, the Office of the Secretary of Defense requested the F/A-22 program to establish a new operational test plan that included measures to ensure the aircraft and its avionics are ready before entering operational testing. In response, the Air Force put in place a two-phase operational test program.

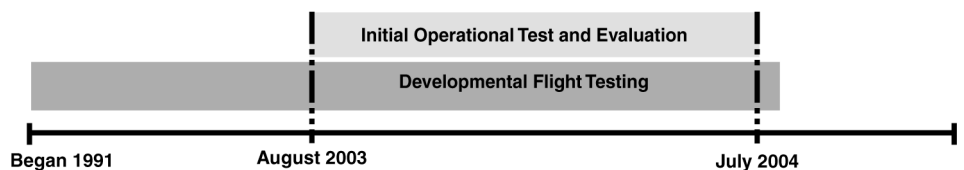
- **Phase 1**, also called an operational assessment, is not the official start of operational testing. It is intended to assess the F/A-22's readiness for IOT&E. Started in October 2003, it calls for testing two F/A-22 aircraft to conduct live air-to-air missile shots, fly one-ship and two-ship formation operational sorties, and assess the computerized maintenance system's maturity. It will include some flight tests that are planned to be repeated in IOT&E if the aircraft configuration changes.

- Phase 2** testing is considered the actual start of IOT&E. To begin this phase, the Air Force must meet a number of criteria. Perhaps most importantly, it must demonstrate that the F/A-22 integrated avionics will be able to operate for sufficient lengths of time, without shutting down. Other criteria that must be met prior to IOT&E include the availability of four fully configured F/A-22 test aircraft and one spare aircraft, the completion of live missile shots, the completion of key aircraft flight envelope testing (planned speed, altitude, and maneuver boundaries of the F/A-22), the completion of operational pilot and maintenance training, a useable system with technical data to fix problems, and the software upgrades to the maintenance system.

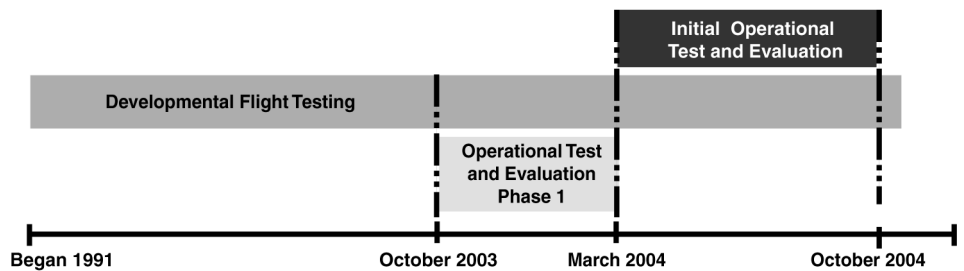
Figure 2 compares the changes in the planned test program since our last report.

Figure 2: F/A-22 Flight Test Schedule Changes

2003 Schedule



Revised Schedule



Source: Air Force.

According to Air Force test officials, results of some phase 1 tests could be used to satisfy IOT&E requirements if the aircraft and software configurations do not change for IOT&E testing. This could reduce the scope of the test effort planned during IOT&E. The Defense Acquisition

Board¹⁸ is scheduled to review the F/A-22's readiness for IOT&E in March 2004.

At the present time, the Air Force expects to complete IOT&E in October 2004, before the full rate production decision, now expected in December 2004. The time allotted to complete IOT&E under the new test plan, however, has been compressed by 4 months, assuming phase 1 testing results are not permitted to be used for IOT&E. This means the Air Force would have less time than previously planned to complete the same amount of testing. If the Air Force continues to experience delays in testing prior to IOT&E, then the full rate production decision would also have to be delayed until IOT&E is complete and the Beyond Low Rate Initial Production Report is delivered to Congress¹⁹. There is no consensus within DOD on the Air Force's ability to meet this October 2004 milestone. The Director of Operational Test and Evaluation, Office of Secretary of Defense, believes the start of testing will slip, although the Air Force maintains it will meet its schedule.

Past Design Problems Corrected

The Air Force has corrected design problems discussed in our March 2003 report. To correct the movement or buffeting of the vertical fins in the tail section of the aircraft, the Air Force designed and implemented modifications, which strengthen the fin and hinge assemblies. Because of this problem, the Air Force placed restrictions on flights below 10,000 feet. Testing was done above and below 10,000 feet, and the flight restrictions were removed. Likewise, the Air Force modified the aircraft to prevent overheating concerns in the rear portion of the aircraft by adding thermal protection and strengthened strategic areas in the aft tail sections. The Air Force also plans to modify later production aircraft using a new venting approach to resolve the heat problems. We reported that the Air Force had also experienced separations in the horizontal tail materials. After additional testing, the Air Force deemed that the original tails met requirements established for the life of the airframe. However, the Air

¹⁸ The Defense Acquisition Board is DOD's senior-level forum for advising the Under Secretary of Defense Acquisition, Technology, and Logistics on critical decisions concerning major defense acquisition programs.

¹⁹ 10 U.S.C. 2399 provides that a major defense acquisition program may not proceed beyond low-rate initial production until initial operational test and evaluation is completed and the defense committees have received the report of testing results from the Director of Operational Test and Evaluation.

Force redesigned the tail to reduce producibility costs. Tests will be performed on the redesigned tail in late 2004.

DOD Did Not Provide Congress Sufficient Business Case Information to Justify Current Aircraft Quantities or Modernization Investment Plans

DOD has not provided Congress with sufficient information to support the business case for buying and modernizing the F/A-22 program. In our testimony of April 11, 2003, before the Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, we stressed that the issue was not whether the F/A-22 should be produced, but rather in what quantities it is needed—as justified by a business case. We discussed the current and future environments in which the F/A-22 investment decision would have to be made, including the need to consider opportunity costs inside and outside DOD. DOD has planned investments over the next several years, on average \$150 billion a year, to keep legacy systems working while at the same time modernizing and transforming U.S. national defense capabilities for the future. The F/A-22 program represents a sizable investment and must compete with other demands within the defense budget. This competition requires a knowledge-based approach to justify acquisition investment decisions and an efficient acquisition process to ensure programs are implemented within expectations set in associated business cases.

Since the start of the F/A-22 program, acquisition costs have increased, the aircraft's mission and key capabilities have expanded, fewer quantities are affordable, and delivery to the user has been delayed. The Air Force currently estimates the total F/A-22 acquisition program will cost about \$72 billion, excluding all costs estimated to complete the spiral improvement effort. Including these costs brings the estimated total investment for the F/A-22 program to about \$80 billion. Through fiscal year 2004, about one-half this investment has been funded.

In light of the changes in the program and investments that remain, the Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, asked DOD to provide a business case justifying the Air Force's planned number of F/A-22s (276 at that time) as well as how many F/A-22s are affordable. In its response, DOD did not sufficiently address key business case questions such as how many F/A-22s are needed, how many are affordable, and if alternatives to planned investments increasing the F/A-22 air-to-ground capabilities exist.

Instead, DOD stated it planned to buy 277 F/A-22s based on a “buy to budget” concept that determines quantities on the availability and efficient use of funds by the F/A-22 program office. Furthermore, justification for expanding the capability, for an estimated \$8 billion to \$12 billion investment, was not addressed in DOD’s response. While ground targets such as surface-to-air missile systems are acknowledged to be a significant threat today, the business case did not establish a justification for this investment or state what alternatives were considered. For example, the F-35 aircraft is also expected to have an air-to-ground role as are planned future unmanned combat air vehicles. These could be viable alternatives to this additional investment in F/A-22 capability.

While the business case information submitted to Congress called for 277 aircraft, DOD stated it could only afford to acquire between 216 and 218 aircraft within the congressionally imposed cap on production costs—currently at \$36.8 billion. DOD expects improvements in manufacturing efficiencies and other areas will provide it with sufficient funds to buy additional F/A-22 aircraft. However, this seems to be an unlikely scenario given the program’s history. Under the “buy to budget” approach, the previous \$876 million increase in development costs was funded by taking funds mostly from production, thus reducing aircraft quantities by 49. With testing still incomplete and many important performance areas not yet demonstrated, the possibility for additional increases in development costs is likely.

Conclusions

While DOD and the Air Force are focused on completing IOT&E and making a decision to go into full rate production, a more basic issue needs to be addressed. The conditions driving the business case that spurred the major investment decision to initially develop and buy 750 F-22 aircraft have changed. A revised and comprehensive business case assessment has not been completed and shared with congressional defense oversight committees. At the present time, it is uncertain how many F/A-22s are needed. The program has been in development for about 18 years, and DOD has invested over \$40 billion. This investment represents about one-half the estimated costs projected for the entire F/A-22 program. Therefore, DOD must still make investment decisions affecting another \$40 billion to support this program through full rate production and implementation of the spiraled modernization effort. Based on current design problems and the development efforts that remain, the F/A-22 program’s affordability is uncertain. Current conditions suggest the Air Force cannot afford to buy much more than 218 aircraft within the cost limitation imposed by Congress.

In light of the uncertainty concerning how many aircraft are needed in today's environment, the large investments that remain, and the unknown outcomes of planned initial operational testing, we continue to be concerned with DOD's readiness to address a December 2004 decision to enter full rate production. Furthermore, IOT&E, intended to demonstrate the F/A-22 effectiveness and suitability, has not started and may not be completed as planned, which may delay the full rate production decision. With this testing outstanding, the risk is high that additional development funding will be needed to resolve problems that could result.

Recommendations for Executive Action

Given the sizable investment that remains in the F/A-22 program, the uncertainties, and the ever changing financial demands of DOD, Congress and the Secretary of Defense would benefit from a comprehensive assessment of the number of F/A-22 aircraft needed as well as assurance that problems identified in initial operational testing will be identified and resolved. Specifically, we recommend that the Secretary of Defense take the following two actions:

- Complete a new business case analysis that determines the continued need for the F/A-22 and that specifically (a) addresses the need for an expanded air-to-ground capability and an assessment of alternatives, to include the feasibility of using other assets like the F-35 and unmanned aerial vehicles planned for the future; (b) justifies the quantity of F/A-22 aircraft needed to satisfy requirements for air-to-air and air-to-ground missions; and (c) provides evidence that the planned quantity is affordable within current budgets and the congressional funding limitation. The Secretary should provide the results of the business case analysis to the defense committees before the decision to start full rate production.
- Before the full rate production decision is made and in conjunction with the Beyond Low-Rate Initial Production Report, provide the defense committees a plan that shows how the Air Force will correct and fund any major problems identified and still open after IOT&E is completed.

Agency Comments and Our Evaluation

In written comments on a draft of this report, DOD stated that it partially concurred with our two recommendations. Regarding our first recommendation on completing a new business case for the F/A-22, DOD stated that it evaluates the F/A-22 business case elements as part of the annual budget process. Additionally, DOD's response acknowledged that this year the department is undertaking a broader set of reviews under the Joint Capabilities Review process; the F/A-22 will be a part of this review.

The President's budget submission to Congress will reflect the results of these review efforts of the F/A-22 business case.

We believe that the various reviews and assessments in the budget process along with the Joint Capabilities Review process present excellent opportunities for DOD to conduct a business case analysis. Other opportunities for completing the business case analysis include the independent and in-depth study requested by the Office of Management and Budget for the Comanche and F/A-22 programs. It is important, however, that the analysis sufficiently address the specific business case elements included in our recommendation—analysis of continued need, need for expanded air-to-ground capability, assessment of alternatives, justification of needed quantities, and evidence that planned quantities are affordable. In addition, it is important that the outcomes of the business case analysis are provided to the Congress prior to the full rate production decision.

Regarding our second recommendation on providing Congress the plans to resolve outstanding problems after the completion of IOT&E, DOD stated that the law already requires the Director, Operational Test and Evaluation, to submit to Congress a Beyond Low Rate Initial Production Report that includes the results of operational testing. Since this report is an independent assessment of test results, the department did not believe it appropriate to include in it Air Force plans and costs for corrective actions stemming from operational testing. However, DOD will present these actions and costs to the Defense Acquisition Board for decisions on the F/A-22 program that will be included in the President's budget submission to Congress.

We understand the legal requirements for submitting the Beyond Low Rate Initial Production Report. We also recognize that this is an independent report submitted by the Director, Operational Test and Evaluation. The intent of our recommendation is not to modify the report itself, but to ensure corrective actions and resultant costs are identified and reported in a timely fashion and before the full rate production decision is made. Because plans and costs could span over several years, such information may or may not be captured in annual budget submissions. We have modified our recommendation to clarify our intent.

Scope and Methodology

To determine changes in the F/A-22 program since its inception, we analyzed cost information from Selected Acquisition Reports and obtained information from the Air Force on its plans to modernize the F/A-22 to include enhanced air-to-ground capabilities. We compared prior cost information with the Air Force's current estimates to complete development and production of the F/A-22.

To determine the impact of development and testing on program outcomes, we examined the extent to which the development program is meeting planned flight test goals for 2003 and the Air Force's planned entry criterion for starting initial operational testing.

In examining sufficiency of the business case DOD provided to a congressional oversight committee, we obtained a copy of the business plan and analyzed the various DOD assumptions and approaches used to make the assessment conclusions.

In making these determinations, assessments, and identifications, we required access to current information about test results, performance estimates, schedule achievements and revisions, costs being incurred, aircraft modifications, and the program's plans for continued development and initial production. The Air Force and the contractors gave us access to sufficient information to make informed judgments on the matters covered in this report.

In performing our work, we obtained information or interviewed officials from the Office of the Secretary of Defense, Washington D.C.; the F/A-22 System Program Office, Wright-Patterson Air Force Base, Ohio; Lockheed-Martin, Marietta, Georgia; the Defense Contract Management Agency, Marietta, Georgia; the Air Force Operational Test and Evaluation Center, Kirkland Air Force Base, New Mexico; and the Combined Flight Test Center, Edwards Air Force Base, California.

We are sending copies of this report to the Secretary of Defense; the Secretary of the Air Force; and the Director, Office of Management and Budget. Copies will also be made available to others on request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

Please contact me at (202) 512-4841 or Michael J. Hazard at (937) 258-7917 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix II.



Allen Li
Director
Acquisition and Sourcing Management

List of Congressional Committees

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The Honorable Carl Levin
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Committee on Armed Services
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Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Comments from the Department of Defense



ACQUISITION,
TECHNOLOGY
AND LOGISTICS

OFFICE OF THE UNDER SECRETARY OF DEFENSE

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WASHINGTON, DC 20301-3000

4 MAR 2004

Mr. Allen Li
Director Acquisition and Sourcing Management
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Li:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "TACTICAL AIRCRAFT: Changing Conditions Drive Need for New F/A-22 Business Case," dated March, 2004 (GAO Code 120239/GAO-04-391).

The DoD partially concurs with the draft report's first recommendation, and partially concurs with the second recommendation. The rationale for the DoD's position is provided at enclosure 1. Enclosure 2 provides additional comments and suggested changes to the report.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, my point of contact for this report is Mr. David Hersh, (703) 697-3619, david.hersh@osd.mil.

Sincerely,

Glenn F. Lamartin
Director
Defense Systems

Enclosures:

1. DoD comments to The GAO Recommendations
2. DoD comments on the Draft Report



GAO Draft Report Dated January 28, 2004
GAO-04-391 (GAO Code 120239)

"TACTICAL AIRCRAFT: CHANGING CONDITIONS DRIVE NEED FOR NEW F/A-
22 BUSINESS CASE"

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense complete a new business case analysis that determines the continued need for the F/A-22, and that the Department provide the results of this analysis to the Defense Committees before the Full Rate Production Decision. (Pg. 24/GAO Draft Report)

DOD RESPONSE: The DoD partially concurs with this recommendation. The Department evaluates the F/A-22 business case, program progress, need for the aircraft, and quantities required, as a part of our routine acquisition and budget processes. These processes include regularly scheduled reviews by the Defense Acquisition Board (DAB). The DAB makes necessary program adjustments that support development of the President's budget. This year, the Department will also be undertaking a broader set of reviews of selected capability areas under the framework of the Joint Capabilities Review process, introduced last year by Secretary Rumsfeld. DoD will be studying major aviation program plans, including F/A-22, as a part of this review. The President's budget submission to Congress will reflect the results of the Department's reviews of the F/A-22 business case.

RECOMMENDATION 2: The GAO recommended that before the Full Rate Production decision, the Secretary of Defense provide the results of the Initial Operational Test and Evaluation testing to the defense committees, along with a plan that shows how the Air Force will correct and fund any major problems identified and still open after this operational testing is completed. (Pg. 24/GAO Draft Report)

DOD RESPONSE: The DoD partially concurs with this recommendation. In accordance with Section 2399 of title 10, United States Code, the Director, Operational Test and Evaluation (DOT&E) will submit a Beyond Low Rate Initial Production (BLRIP) report to the congressional defense committees following Initial Operational Test and Evaluation. The BLRIP report will provide DOT&E's evaluation of the operational testing results, and it may recommend further testing and evaluation. Since the BLRIP report is an independent assessment, it will not include an Air Force plan for corrective action. However, before granting approval of Full Rate Production of the F/A-22, the Defense Acquisition Executive will review the Air Force's plans to correct any deficiencies identified in IOT&E. The President's budget submission to the Congress will reflect these plans.

enclosure (1)

Appendix II: GAO Staff Acknowledgments

Acknowledgments

Marvin E. Bonner, Edward Browning, Roger Corrado, Steve Hunter, Gary Middleton, and Robert Ackley made key contributions to this report.

Related GAO Products

Best Practices: Better Acquisition Outcomes Are Possible If DOD Can Apply Lessons from F/A-22 Program. [GAO-03-645T](#). Washington, D.C.: April 11, 2003.

Tactical Aircraft: Status of the F/A-22 Program. [GAO-03-603T](#). Washington, D.C.: April 2, 2003.

Tactical Aircraft: DOD Should Reconsider Decision to Increase F/A-22 Production Rates While Development Risks Continue. [GAO-03-431](#). Washington, D.C.: March 14, 2003.

Tactical Aircraft: DOD Needs to Better Inform Congress about Implications of Continuing Cost Growth. [GAO-03-280](#). Washington, D.C.: February 28, 2003.

Tactical Aircraft: F-22 Delays Indicate Initial Production Rates Should Be Lower to Reduce Risks. [GAO-02-298](#). Washington, D.C.: March 5, 2002.

Tactical Aircraft: Continuing Difficulty Keeping F-22 Production Costs Within the Congressional Limitation. [GAO-01-782](#). Washington, D.C.: July 16, 2001.

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Defense Acquisitions: Recent F-22 Production Cost Estimates Exceeded Congressional Limitation. [GAO/NSIAD-00-178](#). Washington, D.C.: August 15, 2000.

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